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Original

Overcoming vaccine hesitancy: Evidence from Italy during the COVID-19 pandemic / Del Ponte, A., De Dominicis, A., Canofari, P.. - In: HEALTH POLICY AND TECHNOLOGY. - ISSN 2211-8837. - 14:3(2025). [10.1016/j.hlpt.2025.100996]

Availability:

This version is available at: 11566/355392.11 since: 2026-04-09T11:16:55Z

Publisher:

Published

DOI:10.1016/j.hlpt.2025.100996

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Overcoming Vaccine Hesitancy:

Evidence from Italy during the COVID-19 Pandemic

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Abstract

Objectives: Here we investigate whether releasing COVID-19 vaccines at open-day events boosted Italy's vaccination campaign in 2021. This strategy exploits insights from psychology.

Study design: We built an original dataset covering 200 days of vaccination data in Italy, including "open day" events. Open-day events (in short: open days) are instances where COVID-19 vaccines were released only for a specific day at a specified location (usually, a large pavilion or a public building). Importantly, releasing vaccines through open days instead of the usual appointment channel leaves the supply of vaccines unaltered. Our dependent variables are the number of total and first doses administered in proportion to the eligible population. Our key independent variable is the presence of open-day events in a given region on a specific day.

Methods: We analyzed the data using regression with fixed effects for time and region. The analysis was robust to alternative model specifications.

Results: We find that when an open day event was organized, in proportion to the eligible population, there was an average 0.39-0.44 percentage point increase in total doses administered and a 0.30-0.33 percentage point increase in first doses administered. These figures correspond to an average increase of 10,455-11,796 in total doses administered and 8,043-8,847 in the first doses administered.

25 Conclusions: Releasing vaccines by organizing open-day events was associated with an increase in
26 COVID-19 vaccinations in most Italian regions. These results call for further study of the
27 effectiveness of open days to increase vaccinations and protect against other infectious diseases or
28 future pandemics.

29 **Keywords**: Vaccine hesitancy; COVID-19; vaccinations; open-day events; behavioral public
30 health; Italy

31

32 **Lay abstract**: Here we investigate whether releasing COVID-19 vaccines at open-day events boosted
33 Italy's vaccination campaign in 2021. We built an original dataset covering 200 days of vaccination
34 data in Italy, including "open day" events. Open-day events (in short: open days) are instances where
35 COVID-19 vaccines were released only for a specific day at a specified location (usually, a large
36 pavilion or a public building). Importantly, releasing vaccines through open days instead of the usual
37 appointment channel leaves the supply of vaccines unaltered. We find that administering COVID-19
38 vaccines at open-day events where vaccines are distributed at prominent locations in limited
39 quantities and for a limited time was associated with a statistically significant increase in total and
40 first doses administered. Releasing vaccines by organizing open-day events was associated with an
41 increase in COVID-19 vaccinations in most Italian regions.

42

43

Introduction

44 Vaccines against COVID-19 have been a key pillar of the public health strategy to mitigate the
45 COVID-19 pandemic ¹⁻³, and yet many citizens around the world have been reluctant to get
46 vaccinated ^{4,5}. In response to the complex landscape of vaccine hesitancy, researchers and public
47 authorities around the world have attempted a broad range of communication initiatives and
48 behavioral strategies to encourage citizens to receive the shot ^{6,7}. In this paper, we focus on Italy -the
49 first epicenter of the COVID-19 outbreak outside of China, where vaccine hesitancy has posed a

50 significant public health challenge even before COVID-19 vaccines became available. For instance,
51 in a survey conducted in 2015-2016, about 16% of Italian parents were hesitant or opposed to
52 vaccinating their children ⁸. Two surveys conducted in 2020 in Italy revealed a 31% hesitancy among
53 adults to vaccinate against influenza ⁹ and a 14% hesitancy to vaccinate against a future COVID-19
54 vaccine among university students ¹⁰. At the same time, Italy offers an excellent case study because
55 it lacks the political polarization in vaccine hesitancy and health policy ¹¹ that is seen elsewhere, such
56 as in other European countries ¹² or the United States ¹³⁻¹⁶.

57 In Italy, a key measure to counter COVID-19 vaccine hesitancy was the introduction of ‘open-
58 day’ distribution initiatives overseen by regional administrations ¹⁷. At an open day event, a limited
59 quantity of COVID-19 vaccines are released *only for that day* and at a particular location (typically,
60 a large fair pavilion that accommodates large crowds). Importantly, open-day events leave the supply
61 of vaccines unaltered, but they concentrate the release of vaccines on a single day at a particular
62 location instead of spreading it out over an indefinite period of time (e.g., through vaccination
63 booking portals). Any leftover vaccines go back to the general vaccine supply, if unexpired.

64 The timing of the release of vaccines is crucial to why open-day events can be more successful
65 than regular vaccination campaigns where vaccines are ever available through a booking portal.
66 Amongst many different initiatives and strategies that have been rolled out around the world, open-
67 day events in Italy are interesting from a public health perspective because they build on basic features
68 of human psychology, such as the fear of missing out (FOMO) ¹⁸ and the psychology of scarcity ^{19,20}.
69 Since they exploit basic traits of human nature, these strategies potentially lend themselves to tackling
70 a variety of public health issues. Notably, leveraging natural scarcity or creating FOMO motivations
71 were listed among the strategies for promoting COVID-19 vaccinations proposed by Wood and
72 Schulman in the New England Journal of Medicine (NEJM) in 2021 ⁷. The proposals in the NEJM
73 rest on solid ground in the psychology of consumer behavior ^{20,21} but still await empirical validation.
74 To satisfy this need, in this paper, we leverage a novel dataset on COVID-19 vaccinations in Italy to

75 test the efficacy of open-day events as a strategy to increase the uptake of COVID-19 vaccines in the
76 population.

77 Previous research in the field of marketing found that when consumers have the perception
78 that a product is hardly available, they may attribute a higher value to that product. Thus, companies
79 strategically create perceptions of product scarcity to increase consumers' interest in them. Typical
80 strategies used in marketing include restricting the timing of sales, restricting the quantity released of
81 a given product, or a combination of both strategies ^{20,21}. Creating a sense of scarcity is so vital to
82 boosting sales that famous psychologist of influence Robert Cialdini dubbed scarcity as one of the
83 six principles of persuasion ²². Specifically, a meta-analysis of hundreds of effect sizes in studies of
84 product marketing found that creating a sense that a product is scarce through limited release for a
85 limited time works particularly well when consumption of the product is conspicuous and requires
86 high involvement from the consumer ²¹. COVID-19 vaccines share these features, to the point that
87 people often posted vaccination selfies on social media and shared their post-vaccine experiences
88 ^{23,24}.

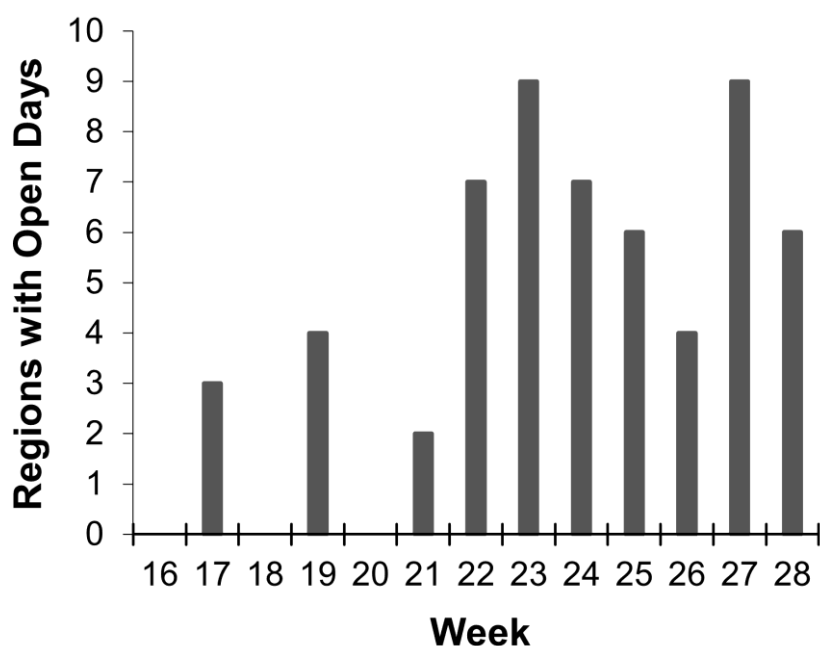
89 Together, insights from psychology and marketing inform the hypothesis that releasing
90 COVID-19 vaccines in limited quantities and for a limited time (open-day events) should increase
91 the administration of COVID-19 vaccines compared to the status quo where vaccines are released
92 outside of these special events. Of course, this *limited-release hypothesis* takes into account the
93 number of vaccine doses available and the number of patients eligible. To test the limited-release
94 hypothesis, we turn to our original dataset from Italy.

95 **Methods**

96 *Dataset*

97 We constructed the original dataset used in this paper starting from daily COVID-19 vaccination data
98 in Italy ranging from December 27, 2020, to July 14, 2021, available on GitHub at the following link:

99 <https://github.com/italia/covid19-opendata-vaccini>. From this dataset, we extracted the vaccine doses
100 delivered to each of the 20 Italian regions; the number of first- and total COVID-19 vaccine doses
101 administered daily; the region where the doses were administered to patients; and information about
102 patient eligibility to get vaccinated. We augmented this dataset with data about open-day vaccination
103 events held between April and July 2021 in each region. We collected information about open-day
104 events from publicly available announcements reported by online local and regional Italian
105 newspapers. In some cases, we were able to collect detailed information about each open-day event,
106 including the city, the exact address (e.g., a hospital), the number of available doses, the brand of the
107 vaccines available, and the age groups at which these initiatives were aimed. However, most of the
108 time, the available data includes only whether a specific number of open-day events were held in a
109 given region on a certain day. Due to the lack of available data, the analysis is not partitioned by
110 vaccine brand and does not include demographic information about vaccine recipients. As a result,
111 our final dataset includes 200 data points (one per day) for each of the 20 Italian regions. Figure 1
112 shows the number of regions that organized at least one open-day event for every week in our sample.
113 The breakdown of open-day events by region is illustrated in Figure A1.



114 **Figure 1.** The number of regions organizing at least one open-day event from the third week of April
115 2021 to the second week of July 2021. The figure shows that the number of regions organizing
116 at least one open-day event peaked in the last weeks of May and June.
117

119 To investigate the relationship between vaccine administrations and open-day events, we
120 examined the period from December 27, 2020, when vaccines started to become available, until July
121 14, 2021, when the data collection ended. We constructed a dichotomous variable that is equal to 1 if
122 at least one open-day event was organized that day, or 0 if no open-day event took place. In our
123 analytical strategy, we study the impact of open day events on COVID-19 vaccinations by using as
124 our main dependent variable the total doses administered/eligible population ratio, where the eligible
125 population includes patients aged 12 or older.

126 Specifically, we estimate the following equation:

$$127 \quad \frac{\text{doses administered}}{\text{eligible population}_{i,t}} = \beta_0 + \beta_1(\text{open day event}_{i,t}) + \beta_2 Z_i + \varepsilon_{i,t} \quad [1]$$

128 where the dependent variable is the ratio between the number of administrations and the number of
129 people eligible to receive the vaccine, $\text{open day event}_{i,t}$ is the open-day dummy variable, Z_i
130 represents unobserved time-invariant heterogeneities across regions, $\varepsilon_{i,t}$ is the error term, and i and t
131 are a region and time index, respectively. We use a panel regression with fixed effects for region and
132 time, since statistically significant Hausman tests consistently showed that the fixed effects models
133 outperformed panel regressions with random effects (a model comparison is available in Table A1).
134 We carried out all our analyses using the Stata 14 statistical software. We report two-tailed tests of
135 significance for all analyses. However, since the limited-release hypothesis is directional, we also
136 report the results of one-tailed tests of significance.

137 **Results**

138 First, we report the descriptive statistics of the study variables. Table 1 shows the main descriptive
139 statistics of the variables present in our dataset. It is worth mentioning a few notable figures. The
140 number of daily doses administered averaged approximately 15,000, with a maximum of 117,252.

141 The dataset includes a binary open-day variable, which keeps track of whether *any* number of open-
142 day events were organized on a given date, and a count variable, which records the specific *number*
143 of open-day events that were organized on a single day. The count variable ranges from 0 to 21 open-
144 day events recorded. The weekend open-day binary variable tracks whether an open-day event was
145 organized on a weekend (Saturday, Sunday) or during the week (Monday through Friday). Figure A2
146 reveals that 45% of open days were held over the weekend (38 on Saturdays and 35 on Sundays).
147 Most open-day events (55%) were held during the week, ranging from 24 on Fridays to 12 on
148 Mondays. As a result, most vaccinations at open-day events occurred on weekdays (51%) relative to
149 the weekend (49%), as seen in Figure A3, although most single-day vaccinations at open-day events
150 happened on Saturdays (27%). In some instances, there were caps on patients' eligibility to receive
151 the vaccine. These caps reflected age targets for vaccine administrations. Minimum age eligibility
152 was as low as 12 years old and as high as 80. Maximum age eligibility ranged from 16 to 100 years
153 old. The number of doses delivered was typically positive but could also be occasionally negative
154 when doses were returned. The number of eligible individuals ranged from just over 100,000 to just
155 shy of nine million, which depends on the population size in a given region. Finally, we report
156 descriptive statistics for the ratios between key measures and the eligible population.

157 Next, we look at the results of our analysis that aims at testing the limited-release hypothesis.
158 When at least one open-day event was present, the total doses administered relative to the eligible
159 population increased by 0.44 percentage points (Table 2). In regions with large populations such as
160 Campania and Tuscany, this effect translates into 22,359 and 14,709 additional doses administered,
161 respectively. Meanwhile, in more sparsely populated regions such as Trentino Alto Adige and
162 Marche, this effect corresponds to 4,188 and 6,012 additional doses, respectively. As a robustness
163 check, in a second model, we control for the doses delivered relative to the eligible population (Table
164 2, model 2). Compared to the previous model, the coefficient for open-day events is slightly smaller,
165 but it always remains positive and statistically significant (0.39 percentage point increase in vaccines

166 administered relative to the eligible population). In an additional robustness check, we add the
 167 weekend open day variable to the model and find that the coefficient for weekend is not significant.
 168 Meanwhile, the coefficient for open-day events remains positive and significant (Table A4).

169 **Table 1.** Descriptive statistics.

Variable	N	M	SD	Min	Max
Doses administered (daily)	3,916	15,012.74	18,892.53	1	117,252
Open day (Yes/No)	4,000	0.040	0.20	0 (No)	1 (Yes)
Open day (Count)	4,000	0.11	0.96	0	21
Minimum age eligibility	144	32.54	18.61	12	80
Maximum age eligibility	144	88.19	22.85	16	100
Doses delivered	2,059	30,917.45	64,327.88	-49,955	779,713
Weekend open day	4,000	0.018	0.13	0 (No)	1 (Yes)
First doses administered	3,916	9,005.31	12,029.30	0	93,189
Eligible individuals	4,000	2,680,845	2,191,825	112,534	8,975,783
Doses delivered/eligible population ratio	2,059	0.011	0.02	-0.01	0.09
First doses administered/eligible population ratio	3,916	0.0032	0.0025	0	0.0139
Total doses administered/eligible population ratio	3,916	0.0055	0.0038	2.56e-07	0.02

170 *Note.* N = observations; M = mean; SD = standard deviation; Min = minimum; Max = maximum. A
 171 negative number of doses delivered means that some doses were returned before being
 172 administered to patients.

173
 174
 175 To further investigate the effect of open-day events on vaccinations, we estimate these models
 176 again, this time using the *number* of open-day events instead of the binary measure of open-day
 177 events. As shown in Table 1, the number of open-day events ranges from 0 to 21 across regions,
 178 allowing us to estimate the marginal effect of organizing an additional open-day event. These models
 179 yield similar results (Table A2). With each additional open-day event, the total doses administered
 180 relative to the eligible population increased by 0.05 percentage points. In highly populated regions
 181 such as Tuscany and Campania, this translates into 1,671 and 683 additional doses, respectively. In

182 less populous regions such as Calabria and Marche, this effect corresponds to 850 and 683 additional
 183 doses, respectively.

184 **Table 2.** Regressions of the *total* doses administered/eligible population ratio on the binary open
 185 day variable and the doses delivered/eligible population ratio.

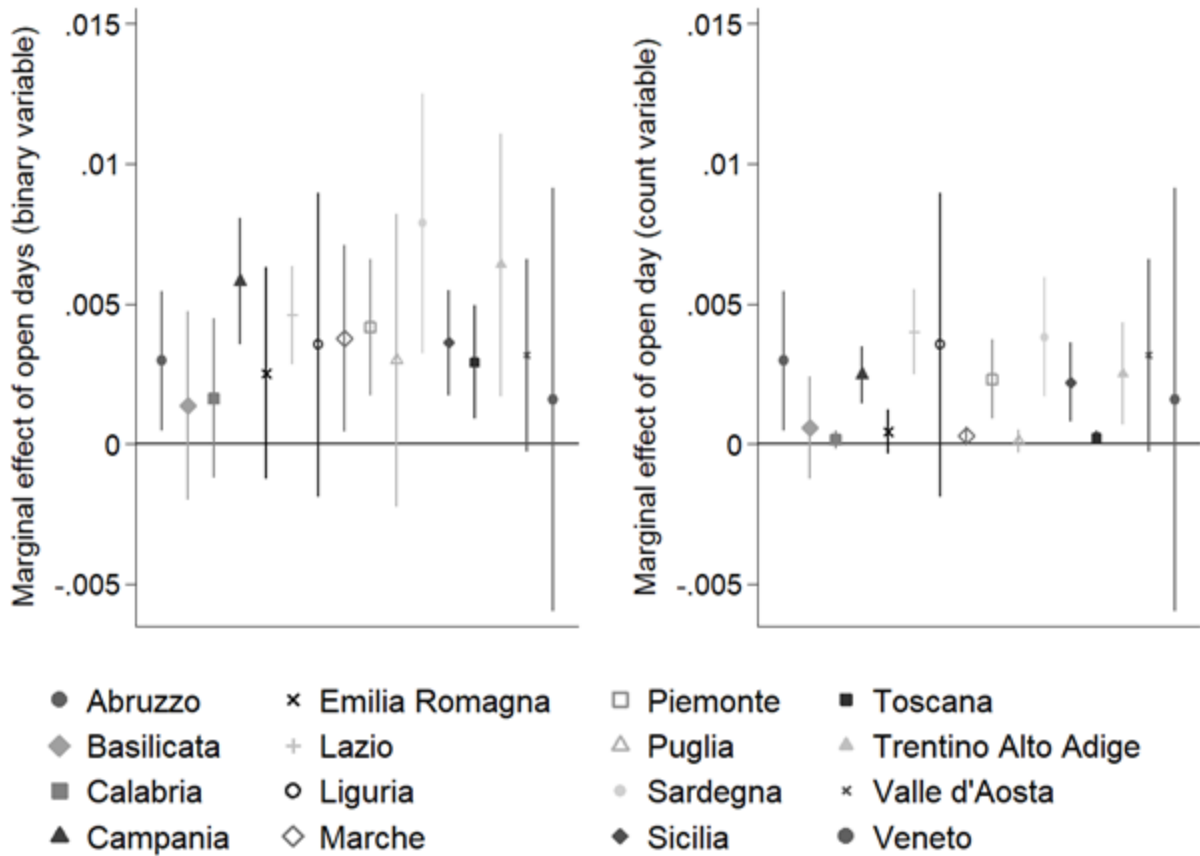
	Model 1		Model 2			
	Coef	SE	Coef	SE		
Open day (Yes/No)	0.0044	0.0003	***	0.0039	0.0004	***
Doses Delivered/Eligible population ratio	–	–		0.0543	0.0048	***
Constant	0.0053	0.00006	***	0.0056	0.00009	***

186 *Note.* Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. The
 187 fixed effects model includes region- and time-fixed effects. * $p < 0.05$ ** $p < 0.01$ *** $p <$
 188 0.001. The significant Hausman test ($p < .001$) indicates that the fixed effects model
 189 outperforms the random effects model.

190
 191
 192 The marginal effect of open-day events disaggregated by region is displayed in Figure 2. The
 193 left panel indicates the marginal effects of organizing at least one open day. The left panel reveals
 194 that the largest effects were in Sardinia, Trentino Alto Adige, and Campania. The open-day
 195 coefficients were positive and statistically significant in most regions (two-tailed tests). Exceptions
 196 include Basilicata, Calabria, Emilia Romagna, Liguria, Apulia, Valle d’Aosta, and Veneto, where the
 197 confidence interval overlaps with zero. However, considering that the hypothesized effect of open
 198 days is positive, when we use a one-tailed test, the coefficient for Valle d’Aosta ($p = .036$) reaches
 199 statistical significance as well. Additionally, with one-tailed tests, the coefficients for Emilia
 200 Romagna ($p = .093$) and Liguria ($p = 0.099$) are marginally significant.

201 The right panel plots the marginal effects of open days using the count variable. Thus, it
 202 indicates the marginal effect of organizing an additional open day. The largest effects of an additional
 203 open day were in Lazio and Sardinia. Consistent with the binary measure, most coefficients were
 204 positive and statistically significant, except in Basilicata, Calabria, Emilia Romagna, Liguria, Apulia,

205 and Veneto (two-tailed tests). When instead we consider the directional hypothesis of a positive effect
 206 (one-tailed tests), the coefficient for Liguria ($p = .098$) is marginally significant.



207
 208 **Figure 2.** The marginal effect of organizing open day events in a specific region on *total* doses
 209 administered. The error bars indicate 95% confidence intervals. The panel on the left shows
 210 the marginal effects of open days using the binary measure (Yes/No). The panel on the right
 211 displays the marginal effects of open days using the count variable, and thus indicates the
 212 effect of organizing an additional open day. Four regions (Friuli Venezia Giulia, Lombardy,
 213 Molise, Umbria) are omitted because no open-day events were recorded there in the period
 214 considered in this study. Significance tests using both one- and two-tailed tests are reported in
 215 Table A7 (left panel) and Table A8 (right panel).

216
 217 Next, we focus on the people who had never been vaccinated against COVID-19 (Table 3).
 218 The results show that, even in this case, the presence of open days is associated with a 0.33 percentage
 219 point increase in first dose administrations, which in a large region such as Tuscany corresponds to
 220 11,032 additional first doses administered relative to the eligible population. Adding the control
 221 variable to this model, the results remain similar, with a 0.30 percentage point increase in the first

222 doses administered. Taking again the example of Tuscany, this is equivalent to 10,029 extra first
 223 doses administered in proportion to the eligible population. A robustness check adding the
 224 (statistically insignificant) weekend open day variable shows a similar pattern to the analysis of total
 225 doses (Table A5).

226 We repeat the analysis of first doses administered by examining the effect of each additional
 227 open-day event instead of the binary open-day event variable. With each additional open-day event,
 228 there was a 0.04 percentage point increase in first dose administrations (Table A3). In a large region
 229 such as Tuscany, this effect corresponds to 1,337 additional first doses administered relative to the
 230 eligible population. Adding the control variable to this model, the results remain similar, with a 0.03
 231 percentage point increase in the first doses administered. Keeping Tuscany as an example, this effect
 232 is equivalent to 1,003 extra first doses administered in proportion to the eligible population.

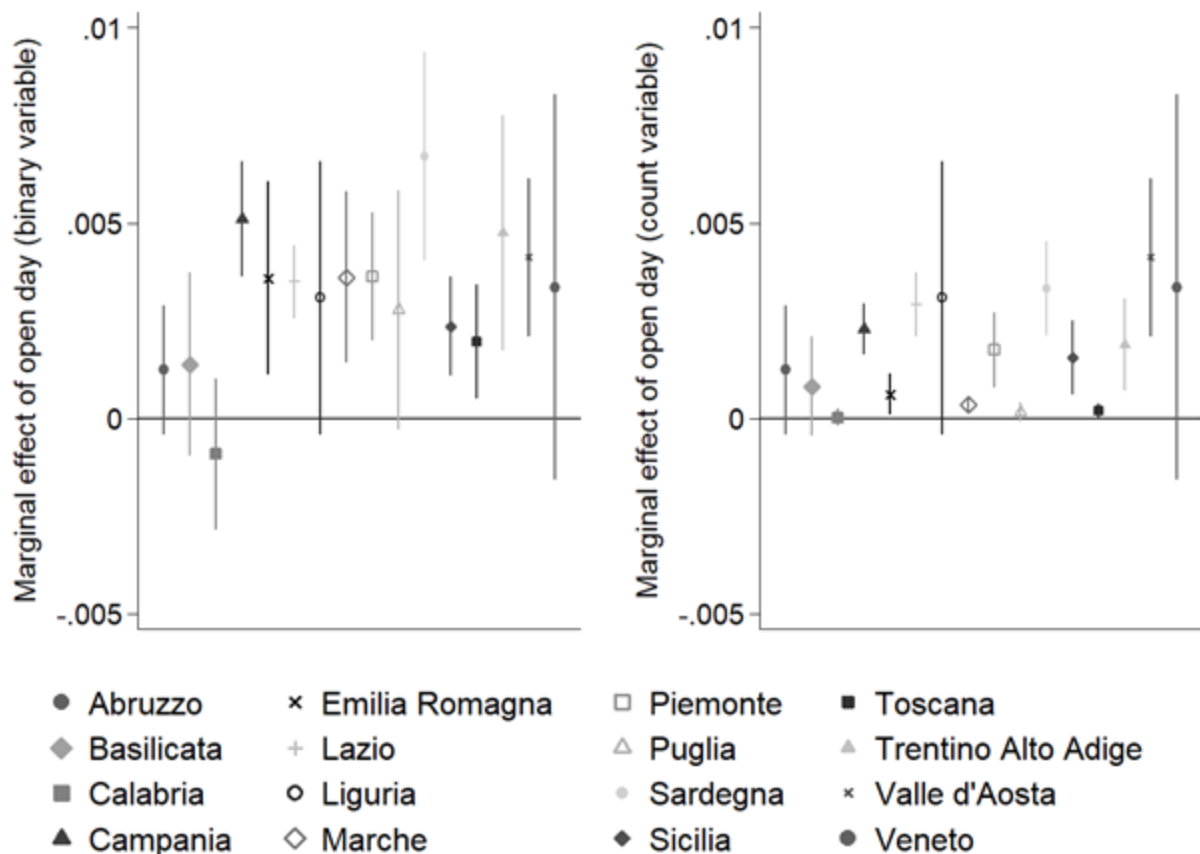
233 **Table 3.** Regressions of the *first* doses administered/eligible population ratio on the binary open day
 234 variable and the doses delivered/eligible population ratio.

	Model 1		Model 2			
	Coef	SE	Coef	SE		
Open day (Yes/No)	0.0033	0.0002	***	0.0030	0.0002	***
Doses Delivered/Eligible population ratio	–	–		0.0304	0.0032	***
Constant	0.0032	0.00004	***	0.0033	0.00006	***

235 *Note.* Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. The
 236 fixed effects model includes region- and time-fixed effects. * $p < 0.05$ ** $p < 0.01$ *** $p <$
 237 0.001. The significant Hausman test ($p < .001$) indicates that the fixed effects model
 238 outperforms the random effects model.
 239

240 We include a graphical presentation of the marginal effects of open days also for the analysis
 241 of the first doses administered in proportion to the eligible population (Figure 3). The left panel shows
 242 the effect of open days using the binary measure. Thus, it graphs the effect of organizing at least one
 243 open day in each region that organized them. We find that the largest effect was in Sardinia,
 244 Campania, and Trentino Alto Adige. Similar to total doses, the coefficient for open days was positive

245 and significant in most regions, this time with fewer exceptions. In Abruzzo, Basilicata, Calabria, and
 246 Veneto, there are no statistically significant effects when using two-tailed tests. However, when we
 247 use one-tailed tests following the directional hypothesis of a positive effect of open days, the
 248 coefficients for Abruzzo ($p = .070$) and Veneto ($p = .090$) are marginally significant.



249 **Figure 3.** The marginal effect of organizing open day events in a specific region on the *first* doses
 250 administered. The error bars indicate 95% confidence intervals. The panel on the left shows
 251 the marginal effects of open days using the binary measure (Yes/No). The panel on the right
 252 displays the marginal effects of open days using the count variable, and thus indicates the
 253 effect of organizing an additional open day. Four regions (Friuli Venezia Giulia, Lombardy,
 254 Molise, Umbria) are omitted because no open-day events were recorded there in the period
 255 considered in this study. Significance tests using both one-and two-tailed tests are reported in
 256 Table A8 (left panel) and Table A9 (right panel).
 257

258
 259 Looking at the marginal effects of organizing an additional open day (Figure 3, right panel),
 260 we find that the largest effects were in Valle d’Aosta and Sardinia. Again, coefficients were positive
 261 and significant in most regions, with even fewer exceptions: Abruzzo, Basilicata, Calabria, Apulia,

262 and Veneto (two-tailed tests). However, considering a directional hypothesis and using a one-tailed
263 test, the coefficients for Abruzzo ($p = .070$) and Veneto ($p = .090$) are marginally significant.

264 Discussion

265 We tested the limited-release hypothesis, which predicts that releasing COVID-19 vaccines in limited
266 quantities on select days (“open days”) boosts the number of doses administered although the supply
267 of vaccines remains unchanged. Using an original dataset of open-day events organized in sixteen
268 Italian regions between April and July 2021, we find support for the limited-release hypothesis: open-
269 day events had a positive effect on vaccinations in most regions. Consistent with expectations, open
270 days boosted administrations of both total and first doses. These effects were robust to different
271 econometric specifications, including the use of fixed or random effects, controlling for doses
272 delivered, accounting for the population eligible to receive the vaccine, and administering the
273 vaccines on open days conducted during the weekend versus weekdays. The results support the
274 proposals by Wood and Schulman in the NEJM to exploit basic features of human psychology such
275 as fear-of-missing-out (FOMO) motivations and the psychology of scarcity in order to increase the
276 number of vaccinations against COVID-19⁷.

277 An alternative interpretation is that open-day events simply make it easier for people to access
278 vaccines. The accessibility interpretation would be misleading, however, because organizing a
279 vaccination distribution at a single pavilion, if anything, *reduces* the convenience of access instead
280 of increasing it, since normally, COVID-19 vaccines are available in pharmacies, doctor’s offices,
281 and hospitals at any given time. Instead, the *timing* of open-day events follows the limited-time offer
282 model that is widely exploited in consumer marketing, since the limited-time component draws
283 consumer interest. For example, previous work found that time-independent promotions fail to
284 accelerate purchases, whereas limited-time promotions quickly attract purchases²⁵. A further
285 indication that the vaccination boost from open-day events cannot be explained away as the result of
286 increased accessibility comes from the fact that 55% of open-day events were held during the week,

287 resulting in 51% of open-day doses administered at weekday open days. If increased accessibility,
288 instead of a sense of urgency, was the main explanation for the results, we would expect a clear
289 majority of open days and open-day doses administered to be on weekends, when most people are off
290 work, but this is not the case. Still, organizing open-day events on weekends, when most medical
291 offices, hospitals, and some pharmacies may be closed or restrict access to the public, may provide
292 expanded access to vaccine doses in addition to exploiting the sense of urgency created by open-day
293 events.

294 It is important to underscore that inducing a sense of urgency through limited-time releases of
295 vaccines in limited quantities at open-day events does not raise any ethical concerns about restricting
296 access to the public. Crucially, open-day events leave the supply of vaccine doses unchanged but
297 concentrate the supply of the doses in a particular place and at a particular time, fostering a sense of
298 scarcity and urgency to get a vaccine. Ethical concerns are also dispelled by vaccination outcomes,
299 which indicate that open-day events boosted vaccinations. In turn, more vaccinations reduce
300 healthcare costs and ultimately save lives. Together, these findings encourage further study of how
301 initiatives that create a sense of scarcity and urgency such as open-day events can help achieve
302 vaccination goals and ultimately improve public health outcomes.

303 **Limitations and Conclusions**

304 This research comes with limitations that future research could address. Importantly, our
305 dataset covers only Italy and is purely observational because the organization of open-day events was
306 not randomly assigned but was instead decided by each region. A possible concern is that regions that
307 were more capable of organizing open-day events self-selected themselves into offering these
308 initiatives. However, this possibility seems unlikely since among the four regions that did not
309 organize there is Lombardy, which is widely recognized as providing one of the best public healthcare
310 systems in Italy ²⁶. More generally, the fact that 75% of Italian regions organized at least one open
311 day mitigates worries about selection effects. Also, in addition to comparisons between regions, our

312 panel dataset allows us to make within-region comparisons for weeks with and without open-day
313 events, which further enhances the validity of the dataset to make inferences about the association
314 between open-day events and an increase in COVID-19 vaccinations.

315 Another possible limitation associated with an observational dataset is that different regions
316 may have organized open-day events differently. For example, some regions may have been more
317 efficient; may have better communicated the rollout of these initiatives with the public; may have
318 given additional small incentives for receiving the vaccinations; or, they may simply have managed
319 these initiatives better overall. These factors may explain why the coefficient sizes differed across
320 regions and why in Calabria - a region which consistently ranks at the bottom in Italy for the quality
321 of healthcare ²⁶, open-day events did not significantly increase vaccinations in proportion to the
322 eligible population. However, in our main analysis, the coefficient for open days was robust to the
323 inclusion of region-fixed effects which capture regional differences. Thus, the robustness of the
324 results to region-fixed effects allays concerns over different implementations of the open day events
325 at the regional level.

326 Finally, another element that may influence vaccination rates is vaccine mandates. In Italy,
327 COVID-19 vaccines became compulsory for healthcare workers in April 2021 ²⁷. While the vaccine
328 mandate increased overall vaccinations, it does not alter the effect of open-day events, which is the
329 focus of the present research. Similar considerations apply to the vaccine mandates for school children
330 rolled out in July 2017 against 10 infectious diseases. While there is suggestive evidence that the
331 mandates increased vaccinations also for non-compulsory vaccines ²⁸, any spillover effect would
332 increase the baseline number of vaccinations but does not affect the impact of open-day events on
333 COVID-19 vaccinations.

334 Overall, these findings suggest actionable insights for how to reach a wider population in
335 future vaccination campaigns against coming pandemics and call for more research on marketing
336 strategies to promote vaccination. Future work could test the effectiveness of limited releases of

337 vaccines in controlled settings, such as laboratory or field experiments, where researchers can reap
338 the benefits of experimental control. To this end, testing the effects on the uptake of vaccines other
339 than the ones against COVID-19 could also prove helpful. Since COVID-19 vaccines have become
340 available only recently, it is plausible that the behavioral effects of limited vaccine releases might be
341 different for vaccines that have been available for decades, such as influenza vaccines. For example,
342 the effects could be larger because of less fear toward the vaccines or smaller because people may
343 consider COVID-19 as a larger health threat than other viruses such as influenza, and thus be less
344 susceptible to FOMO motivations and the psychology of scarcity. We hope that future work will
345 explore these extensions, since vaccinating the largest possible patient population is critical to
346 mitigating or even eradicating many infectious diseases which are a threat to global public health.

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Appendix

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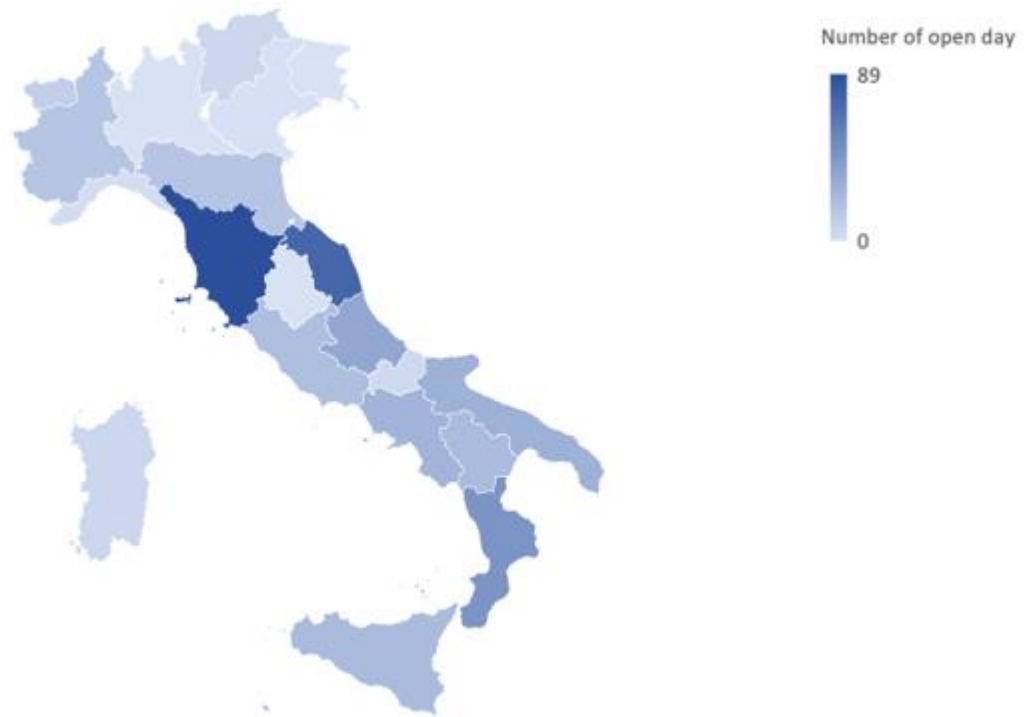
Table A1. Model comparison of the regressions of the *total* doses administered/eligible population ratio on the number of open day events and the doses delivered/eligible population ratio.

407

	Pooled OLS		Fixed Effects		Random Effects				
	Coef.	SE	Coef.	SE	Coef	SE			
Open day (count)	0.00038	0.0001	**	0.0004	0.0001	***	0.0004	0.0001	***
Doses delivered/eligible population ratio	0.0510	0.0029	***	0.0554	0.0049	***	0.0511	0.0049	***
Constant	0.0058	0.0001	***	0.0057	0.0001	***	0.0058	0.0001	***
Hausman Test	No				0.0000				

Note. N = 2,050. Coef. = Beta coefficient. SE = Standard error. The pooled OLS model includes standard errors clustered at the region level. The fixed effects model includes region-fixed effects. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. The significant Hausman test indicates that the fixed effects model outperforms the random effects model.

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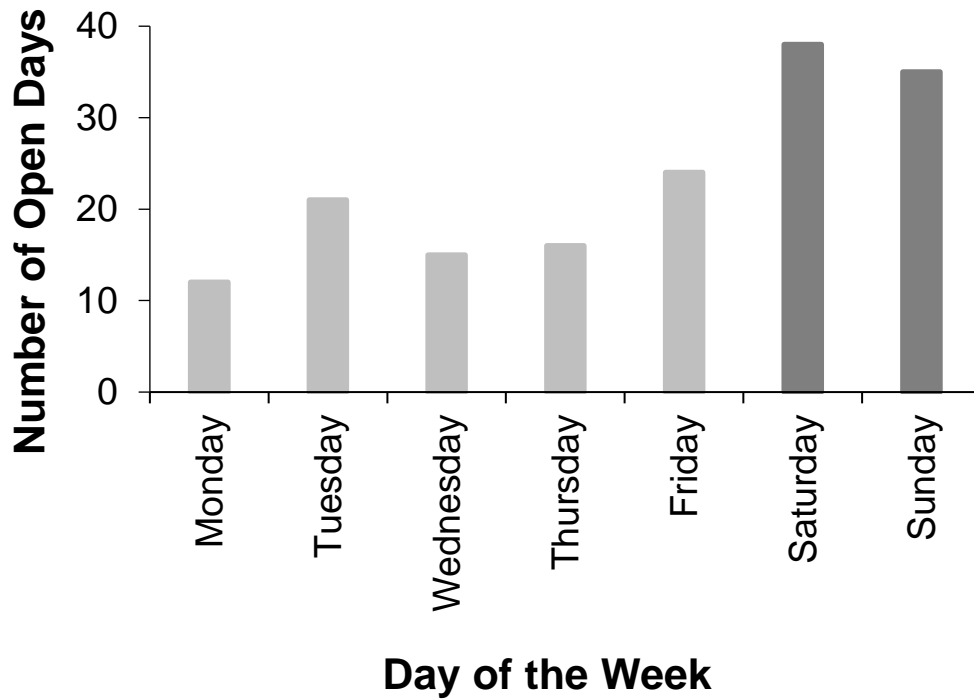


409

410 **Figure A1.** Number of open days in each region (from April 2021 to the second week of July
 411 2021). The figure indicates that Central and Southern Italy organized more open vaccination events
 412 compared to the North, with Tuscany holding the highest number of open days (89).

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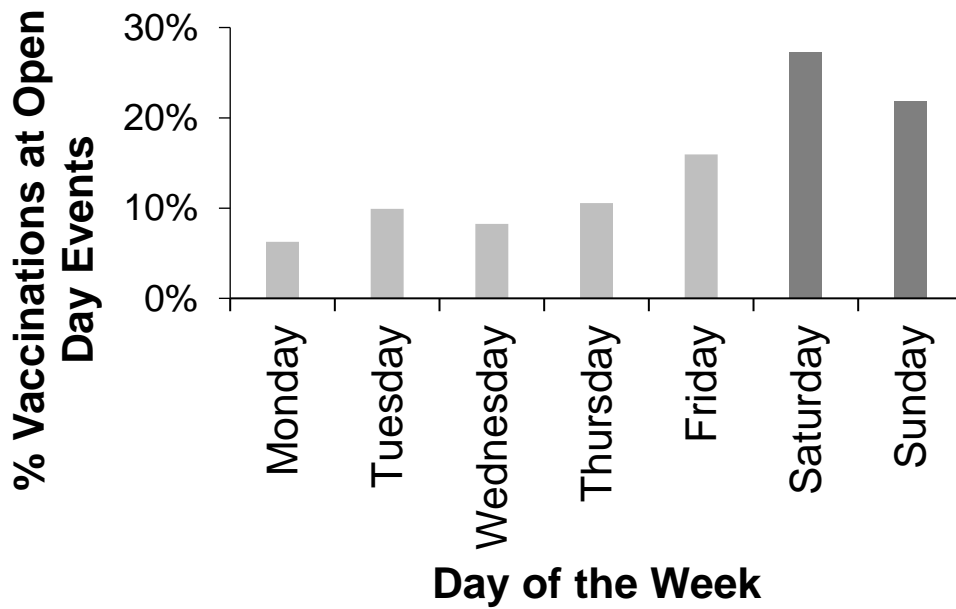


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416 **Figure A2.** Number of open-day events on each day of the week. Weekends are shaded in dark
 417 grey.

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420

421 **Figure A3.** Percentage of vaccinations administered by day of the week during open-day events.
 422 Weekends are shaded in dark grey.

423 **Table A2.** Regressions of the *total* doses administered/eligible population ratio on the number of
 424 open day events and the doses delivered/eligible population ratio.
 425

	Model 1			Model 2		
	Coef.	SE		Coef.	SE	
Open day (count)	0.0005	0.0001	***	0.0004	0.0001	***
Doses delivered/Eligible population ratio	–	–		0.0554	0.0049	***
Constant	0.0055	0.0001	***	0.0057	0.0001	***

Note. Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Models include region- and time-fixed effects. The significant Hausman test ($p < .001$) indicates that the fixed effects model outperforms the random effects model.

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441 **Table A3.** Regressions of the *first* doses administered/eligible population ratio on the number of
 442 open day events and the doses delivered/eligible population ratio.

	Model 1			Model 2		
	Coef.	SE		Coef.	SE	
Open day (count)	0.0004	0.00004	***	0.0003	0.00005	***
Doses delivered/Eligible population ratio	–	–		0.0312	0.0033	***
Constant	0.0032	0.00004	***	0.0034	0.00006	***

Note. Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. * $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$. Models include region- and time-fixed effects. The significant Hausman test ($p < .001$) indicates that the fixed effects model outperforms the random effects model.

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445 **Table A4.** Regressions of *total* doses administered/eligible population ratio on open day events
 446 (binary variable) and the doses delivered/eligible population ratio, controlling for open days
 447 conducted during weekends.

	Model 1			Model 2		
	Coef	SE		Coef	SE	
Open day (Yes/No)	0.0044	0.0004	***	0.0037	0.0004	***
Doses delivered/Eligible population ratio	–	–		0.0545	0.0048	***
Weekend open day (Yes/No)	--	--		0.0005	0.0007	
Constant	0.0053	0.00006	***	0.0056	0.0001	***

448 *Note.* Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. The
 449 fixed effects model includes region- and time-fixed effects. * $p < .05$ ** $p < .01$ *** $p < .001$.
 450 The significant Hausman test ($p < .001$) indicates that the fixed effects model outperforms the
 451 random effects model.

452

453 **Table A5.** Regressions of *first* doses administered/eligible population ratio on open day events
 454 (binary variable) and the doses delivered/eligible population ratio, controlling for open days
 455 conducted during weekends.

	Model 1			Model 2		
	Coef	SE		Coef	SE	
Open day (Yes/No)	0.0033	0.0002	***	0.0028	0.0003	***
Doses delivered/Eligible population ratio	–	–		0.0306	0.0032	***
Weekend open day (Yes/No)	–	–		0.0005	0.0004	
Constant	0.0032	0.00004	***	0.0033	0.00007	***

456 *Note.* Model 1: N = 3,916. Model 2 = N = 2,050. Coef. = Beta coefficient. SE = Standard error. The
 457 fixed effects model includes region- and time-fixed effects. * $p < .05$ ** $p < .01$ *** $p < .001$.
 458 The significant Hausman test ($p < .001$) indicates that the fixed effects model outperforms the
 459 random effects model.

460

461 **Table A6.** Significance of marginal effects on *total* doses administered for the open day *binary* variable
 462 (controlling for doses delivered) using one- and two-tailed tests.

Region	p-value (one-tailed)		p-value (two-tailed)	
Abruzzo	0.009	*	0.019	*
Basilicata	0.211	n.s.	0.422	n.s.
Calabria	0.129	n.s.	0.258	n.s.
Campania	< .001	*	< .001	*
Emilia Romagna	0.093	†	0.185	n.s.
Lazio	< .001	*	< .001	*
Liguria	0.099	†	0.198	n.s.
Marche	0.014	*	0.027	*
Piemonte	< .001	*	0.001	*
Puglia	0.131	n.s.	0.261	n.s.
Sardegna	0.001	*	0.001	*
Sicilia	< .001	*	< .001	*
Toscana	0.003	*	0.005	*
Trentino Alto Adige	0.004	*	0.008	*
Valle d'Aosta	0.036	*	0.072	†
Veneto	0.341	n.s.	0.683	n.s.

Note. * = Significant at the $p < .05$ level or better. † = Marginally significant. n.s. = not significant. All significant and marginally significant effects are positive. See Figure 2, left panel.

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Table A7. Significance of marginal effects on *total* doses administered for the open day *count* variable (controlling for doses delivered) using one- and two-tailed tests.

Region	p-value (one-tailed)		p-value (two-tailed)	
Abruzzo	0.009	*	0.019	*
Basilicata	0.265	n.s.	0.531	n.s.
Calabria	0.162	n.s.	0.325	n.s.
Campania	< .001	*	< .001	*
Emilia Romagna	0.141	n.s.	0.283	n.s.
Lazio	< .001	*	< .001	*
Liguria	0.098	†	0.196	n.s.
Marche	0.048	*	0.096	†
Piemonte	< .001	*	0.002	*
Puglia	0.334	n.s.	0.668	n.s.
Sardegna	< .001	*	0.001	*
Sicilia	0.001	*	0.003	*
Toscana	0.031	*	0.005	*
Trentino Alto Adige	0.004	*	0.008	*
Valle d'Aosta	0.036	*	0.072	†
Veneto	0.341	n.s.	0.683	n.s.

Note. * = Significant at the $p < .05$ level or better. † = Marginally significant. n.s. = not significant. All significant and marginally significant effects are positive. See Figure 2, right panel.

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Table A8. Significance of marginal effects on *first* doses administered for the open day *binary* variable (controlling for doses delivered) using one- and two-tailed tests.

Region	p-value (one-tailed)		p-value (two-tailed)	
Abruzzo	0.070	†	0.140	n.s.
Basilicata	0.121	n.s.	0.242	n.s.
Calabria	0.825	n.s.	1.65	n.s.
Campania	< .001	*	< .001	*
Emilia Romagna	0.002	*	0.005	*
Lazio	< .001	*	< .001	*
Liguria	0.042	*	0.085	†
Marche	0.001	*	0.002	*
Piemonte	< .001	*	< .001	*
Puglia	0.038	*	0.076	†
Sardegna	< .001	*	< .001	*
Sicilia	< .001	*	< .001	*
Toscana	0.004	*	0.009	*
Trentino Alto Adige	0.001	*	0.002	*
Valle d'Aosta	< .001	*	< 0.001	*
Veneto	0.090	†	0.180	n.s.

Note. * = Significant at the $p < .05$ level or better. † = Marginally significant. n.s. = not significant. All significant and marginally significant effects are positive. See Figure 3, left panel.

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473 **Table A9.** Significance of marginal effects on *first* doses administered for the open day *count* variable
 474 (controlling for doses delivered) using one- and two-tailed tests.

Region	p-value (one-tailed)		p-value (two-tailed)	
Abruzzo	0.070	†	0.140	n.s.
Basilicata	0.103	n.s.	0.205	n.s.
Calabria	0.825	n.s.	1.65	n.s.
Campania	< .001	*	< .001	*
Emilia Romagna	0.011	*	0.022	*
Lazio	< .001	*	< .001	*
Liguria	0.042	*	0.085	†
Marche	0.001	*	0.002	*
Piemonte	< .001	*	< .001	*
Puglia	0.116	n.s.	0.232	n.s.
Sardegna	< .001	*	< .001	*
Sicilia	0.001	*	0.002	*
Toscana	0.014	*	0.028	*
Trentino Alto Adige	0.001	*	0.002	*
Valle d'Aosta	< .001	*	< .001	*
Veneto	0.090	†	0.180	n.s.

Note. * = Significant at the $p < .05$ level or better. † = Marginally significant. n.s. = not significant. All significant and marginally significant effects are positive. See Figure 3, right panel.

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